Mid Length vs. Carbine Length Gas System on 14.5" Upper Receiver Group Test – Andrew J. Zirkelbach NSWC Crane

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Mid Length vs. Carbine Length Gas System

Background

- M16 Rifle and later developed M16A1, A2, A3 and A4 variants use a 20” barrel & gas system
- Rifle length gas system uses a gas tube 15” in length with gas port at 13”
- Dwell distance of approximately 7”
- Research concluded the Army should utilize a 14.5” barrel for the M4 & M4A1 carbines
- 14.5” barrel necessitated redesign of M16 gas system utilized in standard 20” M16 barrels
- 14.5” barrel with a rifle length gas system had only 1.3” dwell distance
- Gas port was moved to 7.8” from bolt face on M4 Carbine
- Change gave M4 carbine 6.7” dwell distance
- Decrease in distance from bolt face to gas port of M16 rifle to M4 carbine resulted in an increased port pressure in M4 carbine when compared to M16 rifle
    - Port pressure at 7.8” from bolt face is 17,000 psi
    - Port pressure at 13” from bolt face is 10,000 psi

Mid Length vs. Carbine Length Gas System

Background (cont.)

- **Per interest from United States Army Special Operations Command (USASOC)**

- **14.5-inch barreled Rail Interface System (RIS) II Upper Receiver Group (URG) was assessed for possible conversion from carbine length gas system to mid length gas system**

Mid Length vs. Carbine Length Gas System

Objectives

Evaluation of 14.5” barreled Rail Interface System (RIS) II Upper Receiver Group (URG)

- **Weapon reliability and performance due to change in gas system**
- **Cold Hammer Forged (CHF) Barrels**

Mid Length vs. Carbine Length Gas System

Scope

Data collection and analysis from testing using M855A1 5.56mm to compare performance of Mid Length and Carbine Length gas systems on 14.5” URG

Total of 12,600 rounds per weapon for comparison testing

Testing included:

- **Endurance**
- **Reliability**
- **Precision**
- **Muzzle Velocity**
- **Terminal Velocity (@100 yards)**
- **Bolt Speed**
- **Low Temperature (-60F)**
- **High Temperature (160F)**
- **Barrel Erosion**

Mid Length vs. Carbine Length Gas System

Precision

- **The extreme spread of suppressed mid-length weapons is 0.41 inches, or 9.2%, lower than that of carbine-length weapons. The P-Value between all other results is greater than 0.05, so there is no statistically significant difference between the two gas systems for these parameters. Overall, there is no clear and definitive difference between the precision testing results of carbine-length and mid-length gas systems. Testing was conducted with M855A1 ammunition.**

	Mean Radius, in				Extreme Spread, in			
	Suppressed		Unsuppressed		Suppressed		Unsuppressed	
	Carbine	Mid-Length	Carbine	Mid-Length	Carbine	Mid-Length	Carbine	Mid-Length
Mean	1.37 ± 0.10	1.28 ± 0.06	1.17 ± 0.06	1.20 ± 0.05	4.63 ± 0.38	4.22 ± 0.24	3.83 ± 0.19	3.84 ± 0.17
Difference of Means	-0.09 in or -6.5%		0.03 in or +2.5%		-0.41 in or -9.2%		0.01 in or +0.2%	
P-Value	0.660		0.766		0.035		0.940	

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Muzzle Velocity

- **Averaged results and differences in results of muzzle velocity for all round counts are presented in the Table. The muzzle velocity for carbine-length weapons is 6.7 fps, or 0.23%, higher for suppressed fire and the mid-length is 1.0 fps, or 0.04%, higher for unsuppressed fire.**

	Muzzle Velocity, fps			
	Suppressed		Unsuppressed	
	Carbine	Mid-Length	Carbine	Mid-Length
Mean	2989.7 ± 4.5	2983.0 ± 5.6	2905.4 ± 3.9	2906.4 ± 4.0
Difference of Means	-6.7 fps or -0.23%		1.0 fps or +0.04%	
P-Value	0.384		0.857	

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Terminal Velocity

- **Averaged results and differences in results of velocity at 100 yards for all round counts are presented in the Table. The velocity at 100 yards for mid-length weapons is 32.6 fps, or 1.2%, higher for suppressed fire and 41.6 fps, or 1.6%, higher for unsuppressed fire.**

	100 yard Velocity, fps			
	Suppressed		Unsuppressed	
	Carbine	Mid-Length	Carbine	Mid-Length
Mean	2654.1 ± 6.4	2686.7 ± 9.9	2635.9 ± 6.5	2677.6 ± 8.6
Difference of Means	32.6 fps or +1.22%		41.6 fps or +1.57%	
P-Value	2.52×10^{-25}		1.87×10^{-39}	

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Bolt Speed

- **Averaged overall bolt speeds and differences in bolt speeds are presented in Table. The P-Values of bolt speed results for both suppressed and unsuppressed fire are less than 0.05, so there is a statistically significant difference between the two gas systems. Bolt speed is uniformly lower for mid-length gas systems when compared to carbine-length gas systems. Mid length bolt speed was 2.13 fps, or 12.4%, lower than carbine-length for suppressed fire and 3.23 fps, or 22.6%, lower for unsuppressed fire.**

	Suppressed		Unsuppressed	
	Carbine, fps	Mid-Length, fps	Carbine, fps	Mid-Length, fps
Overall Mean	18.22 ± 0.45	16.09 ± 0.50	15.91 ± 0.43	12.68 ± 0.73
Difference of Means	-2.13 fps or -12.4%		-3.23 fps or -22.6%	
P-Value	4.68×10^{-8}		7.66×10^{-10}	

	Suppressed		Unsuppressed	
Round Count	Carbine, fps	Mid-Length, fps	Carbine, fps	Mid-Length, fps
0	17.18	15.08	14.94	10.99
12600	19.26	17.09	16.88	14.37

Mid Length vs. Carbine Length Gas System

Cyclic Rate of Automatic Fire

Averaged overall cyclic rate of automatic fire and differences in cyclic rate for all round counts is presented in Table. The P-Values of all cyclic rate of automatic fire results are less than 0.05, so there is a statistically significant difference between the two gas systems for these parameters. Mid length cyclic rate of automatic fire was 62.7 rounds per minute (rpm), or 7%, lower than carbine-length for suppressed fire and 127.2 rpm, or 16%, lower for unsuppressed fire. Averaged cyclic rate of automatic fire for ambient temperature testing are similar to overall results.

	Suppressed		Unsuppressed	
	Carbine, rpm	Mid-Length, rpm	Carbine, rpm	Mid-Length, rpm
Mean	944.2 ± 17.4	881.5 ± 12.2	864.8 ± 16.0	737.6 ± 15.1
Difference of Means	-62.7 rpm or -6.9%		-127.2 rpm or -15.9%	
P-Value	4.48×10^{-8}		4.99×10^{-21}	

Mid Length vs. Carbine Length Gas System

Temperature – High & Low

- **960 rounds at 160F for Reliability at High Temp**

-For carbine-length weapons, 5 out of 65 malfunctions occurred during high temperature testing. For mid-length weapons, 1 out of 30 malfunctions occurred during high temperature testing. For high temperature testing, carbine-length weapons had 576.0 mean rounds between failures (MRBF) compared to 836.1 MRBF for ambient temperature testing and mid-length weapons had 2800 MRBF compared to 1993.8 MRBF for ambient temperature testing.

- **960 rounds at -60F for Reliability at Low Temp**

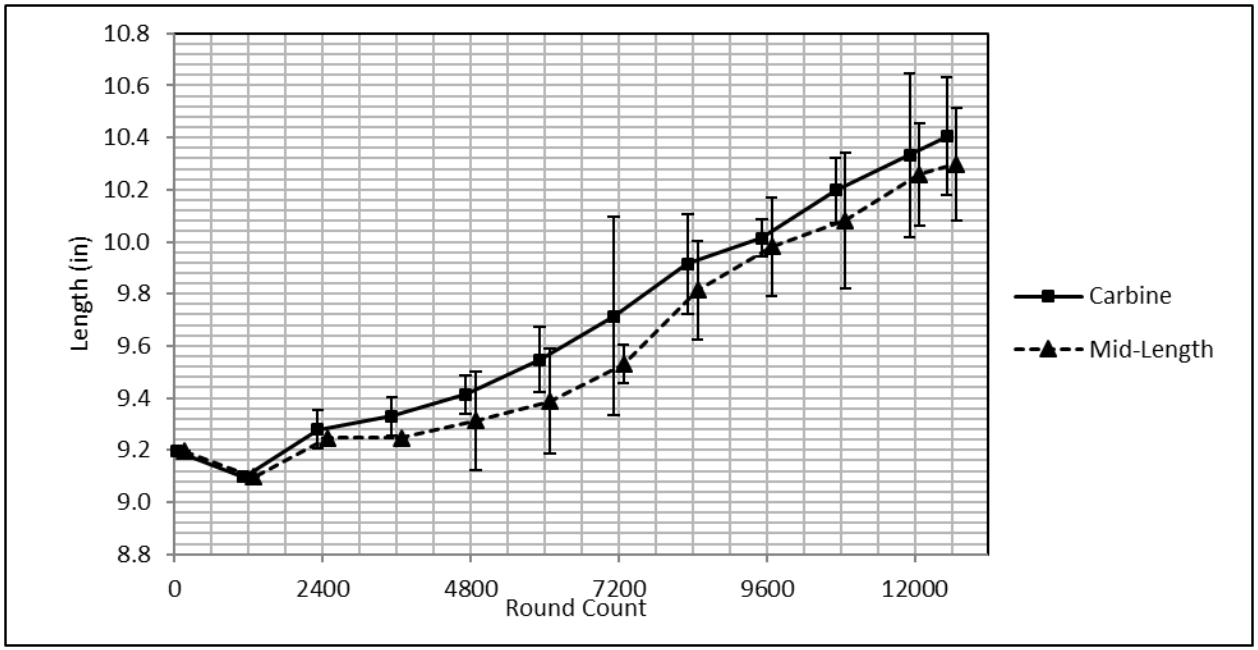
-For carbine-length weapons, 27 out of 65 malfunctions occurred during low temperature testing. For mid-length weapons, 16 out of 30 malfunctions occurred during low temperature testing. For low temperature testing, carbine-length weapons had 333.3 mean rounds between failures (MRBF) compared to 836.1 MRBF for ambient temperature testing and mid-length weapons had 562.5 MRBF compared to 1993.8 MRBF for ambient temperature testing. Approximately half of the total malfunctions recorded for both carbine-length and mid-length weapons occurred during low temperature testing, so the relative rate of malfunctions between carbine-length and mid-length remained similar to that of ambient temperature testing.

- **Data collected during regular firing iterations**

Mid Length vs. Carbine Length Gas System

Barrel Erosion

Measurement of barrel erosion was done using a barrel erosion gauge and measuring the total length of insertion. The total length of insertion is defined to be the length of erosion tool from the extreme end of the tool inserted into the bore of the weapon from the chamber end to the mark read by the operator at the rear edge of the upper receiver assembly when gaged. The barrel erosion gauge total length of insertion was measured every 1200 rounds during endurance testing. The length of insertion of the barrel erosion gage for all round counts for carbine and mid-length weapons is presented below. Note that the first two measurements for carbine-length systems and three measurements for mid-length systems do not have error bars because there was no variance in measurements.



Mid Length vs. Carbine Length Gas System

Endurance & Reliability

- **Carbine-length gas systems experienced a total of 65 malfunctions directly attributable to the weapon and 13 unserviceable parts. Mid-length gas systems experienced a total of 30 malfunctions directly attributable to the weapon and 9 unserviceable parts. The total numbers of malfunctions directly attributable to causes other than the weapon and the total numbers of unserviceable parts are summarized below in Mean Rounds Between Failure (MRBF).**

Malfunction	Carbine-Length	Mid-Length
Failure to fire	10	7
Failure to feed (from magazine)	22	10
Failure to eject	20	4
Bolts fails/hold rear	7	3
All other malfunctions	6	6
Total-Above malfunctions combined	65	30
Mean Rounds Between Failures (MRBF)	581.5	1,260.0

	Ambient Temperature	Low Temperature	High Temperature
Carbine-Length	836.1	333.3	576.0
Mid-Length	1993.8	562.5	2800

Mid Length vs. Carbine Length Gas System

Results

- **12,600 rounds of testing for comparison:**
  - **mid length gas systems experienced a total of 30 malfunctions**
  - **carbine length gas systems experienced a total of 65 malfunctions**
  - **no significant differences between the two gas systems in muzzle velocity**
  - **no significant differences between the two gas systems in terminal velocity**
  - **decrease in bolt speed and cyclic rate of automatic fire for mid length**
  - **no significant differences between the two gas systems in precision or barrel erosion**
  - **high and low temperature testing showed no significant differences (malfunctions, ROF) between two gas systems**
  - **Recommended for use**
  - **Recommended continuation testing for mid length**

Mid Length vs. Carbine Length Gas System

Continuation Testing

- **Continuation testing on Mid Length in process at Crane**

- 30k+ rounds and going

Mid Length vs. Carbine Length Gas System

Questions / Comments

- **Questions / Comments - ?**